# Phytoplankton Biomass, Zooplankton, and Larval Fish Assemblages Associated with the Yucatan Upwelling Area

Andrew W. David[1], Churchill B. Grimes,[1] Thomas D. Leming,[2] Guillermo Ortuno,[3] and Aurora Monreal[4]

## Abstract

The persistent upwelling area generated by the Yucatan Current sweeping up the continental shelf off Isla Mujeres and over the Campeche Bank creates an increased abundance of forage which should aid growth and survival of larval and juvenile fishes, and boost recruitment to the fishery resources in southeastern Mexico. Federal scientists from the U.S. (NMFS) and Mexico (INP) conducted a detailed ichthyoplankton survey of this area in January-February 1990. Satellite imagery revealed a plume of cool water (2.0-2.5°C below surrounding waters) 10-15 km wide by 45 km long generally running SE to NW. Real-time radio telemetry of satellite imagery data to the research vessel allowed five survey tracks to be chosen on-site for optimal coverage of the upwelling area. Macrozooplankton and phytoplankton (by chlorophyll a) were collected along with hydrographic vertical profiles. Ichthyoplankton was collected with 1 x 2-m neuston (mesh = 957 μm) and 60-cm bongo (mesh = 333 μm) nets. Chlorophyll a and macrozooplankton were strongly negatively correlated with SST, r = -0.85 and r = -0.41, respectively. Ten families, including the economically important scombrids, carangids, and mugilids, comprised 75.6% of ichthyoplankton collected, of which 60% were pelagic species and 40% demersal species. Chlorophyll a, macrozooplankton, and ichthyoplankton peaks were sequentially shifted downcurrent (NNW) from the most intense upwelling area.

## Introduction

The rich fishing grounds of the Campeche Bank provide large catches of grouper, snapper, grunts, porgies, and lobster, but very little fishery research has been conducted in this area (Sanchez-Velasco and Flores-Coto, 1994; Richards et al., 1993; Rodriguez-Capetillo et al., 1997) (Figure 1). In January and February 1990 NMFS and INP conducted a joint ichthyoplankton survey of the Yucatan coast of the Gulf of Mexico. The objectives of this cruise were threefold, (1) to collect in situ and remotely sensed environmental data in the Yucatan upwelling area, (2 ) to determine the distribution and abundance of phytoplankton, zooplankton, and larval fish assemblages, and (3) evaluate the potential effect on recruitment to the valuable Campeche Bank fishing grounds.

The upwelling is created when the Yucatan Current collides with the eastern escarpment of the Campeche Bank. Several authors have examined the physical oceanography of the area examined in this study (Hamilton, 1991; Lewis et al., 1991; Monreal-Gomez and Salas-de Leon, 1990; Molinari and Morrison, 1988). The current flows up from the 2,000 m depths of Yucatan Channel and over the bank bringing cold nutrient-rich water to the surface triggering a proliferation of marine life exceeding that found in adjacent waters. The Campeche Bank is roughly 600 km wide and extends approximately 250 km offshore. This carbonate platform remains relatively shallow as depths of 100 m are common 180 km offshore. Contrasting this is the very narrow shelf on the eastern side of the peninsula where depths exceeding 200 m are common just a few kilometers off the beach. This upwelling is persistent throughout the year although

[1] National Marine Fisheries Service, 3500 Delwood Beach Rd, Panama City, FL 32408
[2] National Marine Fisheries Service, Bldg 1103, Rm 218, Stennis Space Center, MS 39529
[3] Inst. Nat. de la Pesca Programa Planeton, Dr. Valenzuela (85) Col. Doctores, Mexico D.P. C.P. 06720
[4] Inst. Nat. de la Pesca, Sub. Technologe de Capturon, Dir. de Inv. y Dramo 16 Tec., Dr. Valenzuela (85), Col. Doctores, Mex. D.F. C.P. 06720

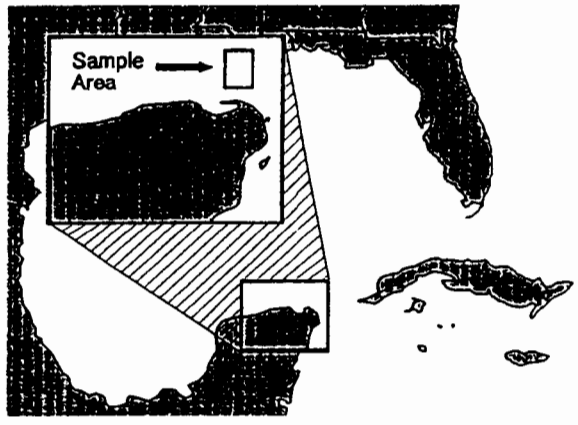


*Figure 1. Sampling area.*

there is some variation in the location of the surface temperature minimum due to shifts in the prevailing wind direction.

Samples were collected at 49 stations during 4 days in February of 1990. The sampling area was 74 km along the north-south axis and 93 km along the east-west axis. Four transects of ten stations were run beginning in the southeast and proceeding northwestward, a fifth transect was also surveyed on the eastern edge of the Campeche Bank where nine stations were surveyed. The transects were 18 km apart and the stations were 7.5 km apart within the transects. Real time satellite imagery of sea surface temperature was used to select the survey transects and to confirm the seasonal persistence of the upwelling. Hydrographic and phytoplankton data were collected with a CTD and Niskin bottle array. Zooplankton and ichthyoplankton were collected with 60 cm bongo nets with 333 μm mesh and 1.0 x 2.0 m neuston nets with 947 μm mesh. All net catches were preserved in ethanol.

There was a 3°C depression in the surface temperature in the center of the southern half of the survey area where cold upwelling water of the Yucatan Current reached the surface. In addition to the thermal differences, the water in the upwelling area was noticeably green in contrast to the clear blue water of the nearby Caribbean. The spatial displacement of the surface temperature minimum from the edge of the shelf reflects the high velocity of the Yucatan Current which can be as high as 2.5 meters per second. Phytoplankton concentration, based upon chlorophyll a values, showed a very strong negative correlation to surface temperature with an r value of -0.85. The surrounding Caribbean water had much lower values of chlorophyll a, typically less than 0.15 $\mu g \cdot l^{-1}$ compared to levels of nearly 2.00 $\mu g \cdot l^{-1}$ in the upwelling area. The phytoplankton maximum was approximately 50 km downcurrent from the maximum upwelling. Zooplankton concentrations were elevated in the southwest of the upwelling, displaced slightly downcurrent from the phytoplankton maximum. Zooplankton values were determined by settlement volumes taken from the bongo nets. As with chlorophyll a, there was a strong negative correlation with sea-surface temperature although the relationship, with a value of -0.41, was not as strong as with chlorophyll a.

Not surprisingly, larval fish responded to the enriched nutrients, phytoplankton, and zooplankton. The bongo-collected ichthyoplankton maximum was shifted farther downcurrent still from the zooplankton maximum and about 67 kilometers from the maximum upwelling. There were 4,809 fish collected with the bongos. The neuston ichthyoplankton collections displayed a prominent peak in the southwest corner with a smaller peak farther north along the western boundary of the sampling area (Figure 2). There were over 6,300 fish collected with the neuston nets representing at least 43 families. The ten most abundant families accounted for 77% of the total fish collected. These ten families in descending order of abundance were: Exocoetidae (1,220), Carangidae (761), Atherinidae (584), Mugilidae (430), Clupeidae (396), Scombridae (283), Sparidae (267), Blenniidae (167), and Gerriidae (139). Four of these families were generally at their maximum in the southwest, the Blenniidae, Carangidae, Sparidae, and Clupeidae; three families, the mullids, scombrids, and mugilids had maximum densities along the central and northwestern stations; and three families had more random distributions that were not easily categorized, the most abundant family, the Exocoetidae, as well as the atherinids and the gerriids. There was a good mixture of pelagic families

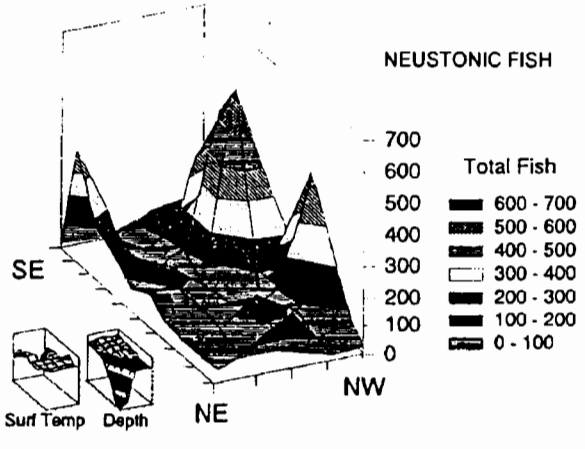


*Figure 2. Distribution of larval and juvenile fish.*

you would expect to see offshore, the exocoetids, scombrids, and carangids as well as demersal families often associated with reef areas, the sparids, mullids, and Blenniidae. The sequential displacement of peak phytoplankton, zooplankton, and ichthyoplankton biomass downcurrent from the most intense upwelling demonstrates the temporal lag of primary and secondary producers and then fish in responding to the nutrient enrichment.

When we summarize these results there are several points we can make: (1) the upwelling area has a surface temperature minimum that was 2.0-2.5 degrees below the surrounding water, (2) the cool water plume was 10-15 km wide and 45 km long along a northwest-southeast axis, (3) the maximum surface chlorophyll a readings were strongly associated with the surface temperature minimum, (4) the macrozooplankton maximum was shifted slightly downcurrent from the chlorophyll a maximum, and (5) the ichthyoplankton peaks were shifted slightly downcurrent from the zooplankton and somewhat farther from the chlorophyll a maximum.

The Yucatan Current impacts the continental shelf off Isla Mujeres which forces cold nutrient-rich water up from over 1,500 meters onto the 35-55 meter deep Campeche Bank. This persistent influx of nutrients from the upwelling, augmented with coastal upwelling due to Ekman transport, drives increases in phytoplankton, zooplankton, and ichthyoplankton on the Campeche Bank as the current flows westward. The increases in prey types and amounts which are available due to the upwelling-supplied nutrients are likely to increase the recruitment success of all fishes including commercially important species such as scombrids, carangids, and mugilids by imparting a trophic advantage of faster growth and decreased larval stage duration over larvae in the surrounding nutrient poor waters. It is also possible that larger ecosystem scale benefits are imparted to the Campeche Bank by this upwelling feature in that fishes normally associated with upwelling area, i.e., small pelagics such as anchovy, are not here in great numbers perhaps due to the shallow water, and that instead the large demersal stocks associated with the benthic community are the primary beneficiaries of the increased primary and secondary production.

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